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Case Report

Possible cause of low-inspired oxygen concentration during end-tidal controlled low- flow anesthesia technique with the aisys CS^2 anesthesia machine: Case report

End-tidal controlled low flow anesthesia

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Abstract
It is reported that climate change, which is considered the biggest global health threat in the twenty-first century, can only be prevented by applying sustainability in healthcare. Sustainability in anesthesia can be achieved by anesthetists who control the flow of inhalation agents while meeting our daily needs, accept low-flow anesthesia (LFA) as the current anesthesia management method of our age and transfer their principles, knowledge and methods to practical applications in order to make the development sustainable. In this case report, we planned to present a brief case of temporary desaturation, which was immediately noticed during end-tidal controlled LFA applied with the GE Aisys CS^2 anesthesia device and LFA, a component of sustainable anesthesia, in summary.

Keywords
General Anesthesia, Low Flow Anesthesia, End-Tidal Controlled Anesthesia

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Introduction

Due to environmental and economic concerns globally, the popularity of sustainability and, therefore, the concept of sustainable anesthesia is increasing. One of the most important components of sustainable anesthesia is Low Flow Anesthesia (LFA). With this anesthetic technique, the consumption of gas and inhalation agents is minimized, and a significant amount of cost and reduction in atmospheric pollution can be achieved. In addition to its many advantages, LFA also contributes to intraoperative protective lung mechanical ventilation techniques by improving the anesthetic gas climate and maintaining heat and humidity [1]. Low-flow inhalation anesthesia can be administered with manual or end-tidal controlled methods. End-tidal controlled anesthesia devices automatically adjust the O_2 flow and end-tidal concentrations of inhalation anesthetics set in the application of inhalation anesthesia by feedback and feeding. Less intervention is of clinical importance, similar to eliminating user distraction, record keeping, and patient safety [2]. This case report aimed to present a possible problem during the end-tidal controlled LFA application in a training and research hospital providing residency training.

Case Report

Radical abdominal hysterectomy was planned by the gynecology-oncology clinic for a 56-year-old patient weighing 86 kg due to endometrial carcinoma. During preoperative evaluation, the patient who had no concomitant disease other than the diagnosis of hypertension for four years was evaluated as ASA 2, and informed consent was obtained. The patient, taken to the operating table on the day of the operation, underwent standard anesthesia monitoring (ECG, non-invasive blood pressure, arterial pressure, pulse oximetry) , and 2 mg of midazolam iv was administered for premedication. In our institution, after reviewing the Low-Flow Anesthesia checklist (Figure 3), standard anesthesia induction (fentanyl 2 mcg/kg, lidocaine 1 mg/kg, propofol 2 -2.5 mg/kg, and rocuronium 0.6 mg/kg) was induced after three minutes of preoxygenation (Tidal volume method, 80% O_2) was applied. After anesthesia induction, the patient was intubated with an endotracheal tube and connected to the GE Healthcare Aisys CS^2 (F-890781) anesthesia device, and the lungs were mechanically ventilated (PCV mode) with TV 6-8 ml/kg and End-tidal CO_2 30-35 mmHg. The lower and upper alarm limit values of the parameters monitored on the monitor were adjusted for the patient. Anesthesia was maintained for the first 5 minutes with a fresh gas flow of 4 L/min, 50 % O_2 + 50 % air, and 2.5% sevoflurane. Remifentanil infusion was administered to provide intraoperative analgesia. After five minutes, the flow was reduced to 800 ml/min (50 % O_2+ 50 % Air). In the following period, the anesthesia assistant informed the responsible specialist that the FiO_2 decreased to 28% and gave an alarm. Meanwhile, SpO_2 decreased from 98% to 94% (Figure 1, 2). The device was checked for possible causes, minute ventilation, expired tidal volume, airway peak pressures were reviewed, and no problem was detected in all these values. In the evaluation made by the specialist, it was noticed that the assistant adjusted the end-tidal O_2 by 34% when the flow was reduced to 800 ml/min, thinking that end-tidal controlled ventilation was switched, and adjusted the O_2 fresh gas flow to 34% in the fresh gas flow with manual control. After this situation, the fresh gas flow was increased to 4 L/min for a short time by remembering the long-time constant in low-flow anesthesia by the specialist physician. Then, the flow was reduced to 800 ml/min again, and the problem was resolved by switching to end-tidal controlled mode (End-tidal O_2 35%, End-tidal sevoflurane 1.7-2 %, MAC 0.8-0.9). During the anesthesia (4 hours), the alarm lower and upper limit values of the parameters set on the monitor were not reached again. After the first 3 hours of the operation, the gas flow was increased to 2 L/min for 30 minutes, and then reduced to 800 ml/min again and continued at 800 ml/min until the end of the surgery. In the last 15 minutes of the operation, remifentanil was stopped by intravenous administration of 10 mg of morphine sulfate and 1 g of paracetamol to provide acute postoperative analgesia. Fresh gas flow was continued at 4 L/min for the last 5 minutes before awakening, and the sevoflurane vaporizer was turned off, and the patient was extubated without any problems.

Figure 1. Adjusted O_2 concentration of 34% in fresh gas (manually controlled LFA)

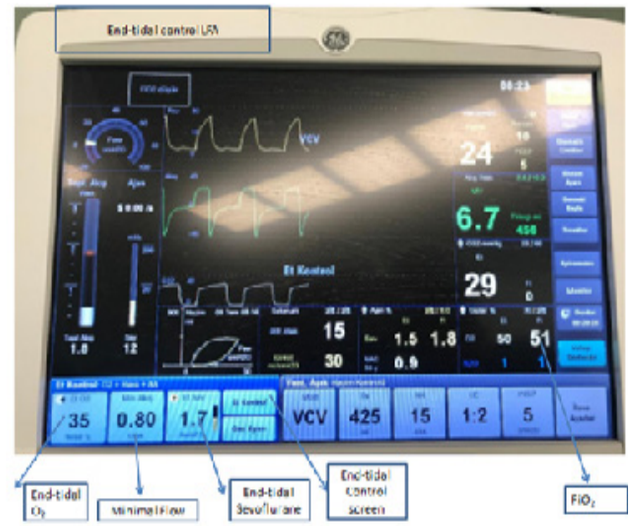

Figure 2. After the increase in the flow rate and in FiO_2 (long time), the flow rate is decreased at 800 ml/min (end-tidal controlled LFA).

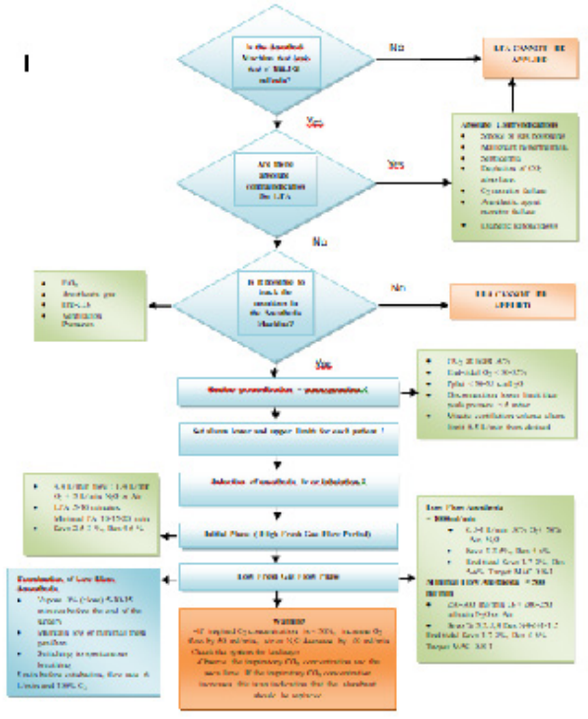

Figure 3. Low-Flow Anesthesia (LFA) Check List

Discussion

Sustainability is to meet our own needs without compromising the needs of future generations, and today, we see that more and more publications on sustainability in anesthesia take place in the literature. The General Medical Council of England stated that trained physicians should transfer the principles, knowledge, and methods of sustainable health care into their practical applications [3]. Inhalation anesthetics are thrown into the atmosphere after use and remain in the atmosphere for years, contributing to climate change. Vollmer et al. reported measured atmospheric concentrations of inhalation anesthetics and showed that desflurane pollution gradually increased, sevoflurane remained static, and isoflurane decreased [4]. Anesthesiologists are closely related to the use of resources, and due to the applied nature of the specialization, inhalation anesthetics have important contributions to the control of the fresh gas flow and thus to the environmental effects. In this context, it is reported that anesthetists should use LFA to contribute to environmental sustainability.

In our department, an education and research clinic, sustainability and LFA education is given theoretically and practically in the first years of residency training. LFA applications can be applied with all modern anesthesia devices that meet the American Society for Testing and Materials ASTM F1850–00-2005 and the European Standard EN 740 requirements [5].

Various smart visuals and alarm limits are available on different anesthesia machines to minimize human-induced errors in general anesthesia applications. As in our case, adjusting the upper and lower alarm limits for each patient undergoing general anesthesia in the initial period of anesthesia is important for the early detection of possible complications. It is mandatory to monitor the inspired O_2 concentration, airway pressures and/or minute ventilation volume, and the concentration of inhalation agents in the circuit in this anesthesia technique [1]. The oxygen concentration in fresh gas should be adjusted to at least 50% in low-flow anesthesia and 60% in minimal-flow anesthesia. In our case, all alarm lower limits (FiO_2 30%, minute ventilation lower alarm limit 500-600 ml/minute below the existing minute ventilation value) were explicitly set for the patient during the initial period of anesthesia, and possible problems were investigated when FiO_2 went below the set lower limit value. In addition to the many advantages of the Low Flow Anesthesia technique, one of the disadvantages claimed is the possibility of developing hypoxemia. In this technique, concentration changes in the fresh gas take a long time to cause the concentration change in the ventilation system (long time constant), which will create an extraordinary safety factor. However, today's modern anesthesia machine and the anesthetist's sufficient knowledge, and experience, in LFA reduce the probability of experiencing the alleged negativities.

Modern but expensive inhalational anesthetics such as desflurane and sevoflurane can be used safely and effectively in low-flow anesthesia techniques. Although Compound A, a degradation product formed by sevoflurane in LFA, is nephrotoxic in rats, its toxicity in humans has not been reported due to LFA use for a long time. Especially with the relatively new CO_2 absorbents that do not contain KOH and, to a lesser extent, NaOH, Compound A is either not formed at all or to a lesser extent. Kobayashi et al. compared Draegersorb Free (NaOH < 2%) to Amsorb [$Ca(OH)_2$] alone and found no difference in the amount of Compound A produced. Another study showed that Compound A levels in the circuit are reduced by using CO_2 absorbents with reduced amounts of strong bases or eliminated by those without NaOH. Interestingly, they found that desiccation reduced Compound A produced when NaOH was present, increasing with $Ca(OH)_2$ alone [6]. In our clinic, the CO_2 absorber KNGSORB (contains calcium hydroxide, sodium hydroxide, and ethyl violet) is used, and we do not have any concerns about Compound A formation since it does not contain KOH.

Checklists for routine situations in healthcare practice are organizational aids in complex tasks. It helps eliminate a decrease in performance and assists the individual user by providing standardized baseline information [7]. Training in training and research hospitals is one of the core activities of these hospitals, and in this context, checklists also assist in residency training. We believe that the checklist created for LFA applications in our clinic contributes to the training in the initial period of residency training (Figure 3).

There are two low-flow anesthesia technique application methods: manual control and end-tidal control. Manually controlled low-flow anesthesia can be defined as a method in which oxygen and anesthetic gas titration are constantly controlled by the anesthetist, and manual adjustments are made to ensure adequate depth of anesthesia. In manually controlled low-flow anesthesia, many anesthetic gas dosage adjustments are required to ensure safe and appropriate anesthesia. End-tidal controlled low flow anesthesia is a method applied with advanced technological anesthetic devices, in which target fresh gas flow and the amount of end-tidal anesthetic gas are entered into the device, and the device automatically makes changes in the flows to achieve the target values. Less

intervention of the anesthetist to the device may be clinically more important for patient safety and record keeping.

In our case, checklists must be created during anesthesia with the GE Aisys CS² anesthesia machine. Again, we believe that the digital display adjustment buttons should be more prominent to avoid potential problems during the transition period from manual control technique to end-tidal control technique in this anesthesia device.

In conclusion, we think that sustainability in anesthesia and its component LFA technique, which is becoming more and more important for a sustainable environment, possible problems and checklists during the transition to manual and end-tidal controlled modes during anesthesia device training should be given from the early stages of assistantship.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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